

CLAIMS

What is claimed is:

1. A catadioptric projection lens for imaging a pattern situated in an object plane of the projection lens onto an image plane of the projection lens while creating a real intermediate image, comprising:

a catadioptric section with a concave mirror and a beam-deflector located between said object plane and said image plane; and

a dioptric section arranged following said beam-deflector;

said dioptric section starting after a final reflective surface of said catadioptric section and comprising at least one lens arranged between said final reflective surface and said intermediate image; and

said beam-deflect or being a geometric beam splitter having at least one reflective surface.

2. A projection lens according to claim 1, wherein said intermediate image is situated in an empty space at a distance from an optical component nearest said intermediate image.

3. A projection lens according to claim 1, wherein said intermediate image is freely accessible.

4. A projection lens according to claim 1, wherein said intermediate image is situated at a distance from a final reflective surface of said beam-deflector, where said distance is chosen such that the diameter of rays incident on a surface orthogonal to the

optical axis at an intersection of said final reflective surface with said optical axis is at least 10 % of the diameter of said concave mirror.

5. A projection lens according to claim 1, wherein positive refractive power is arranged between said final reflective surface and said intermediate image.

6. A projection lens according to claim 1, wherein a front lens is inserted on the object side ahead of said intermediate image and a rear lens is inserted on the image side following said intermediate image and wherein the front lens and the rear lens are roughly symmetrically arranged with respect to said intermediate image such that asymmetric contributions to imaging aberrations by the front lens and the rear lens due to heating of the front lens and the rear lens are at least partly compensated.

7. A projection lens according to claim 1, wherein there is provided at least one lens of said dioptric section having a surface facing said intermediate image, the surface being spherical.

8. A projection lens according to claim 6, wherein surfaces of the front lens and the rear lens facing said intermediate image are spherical.

9. A projection lens according to claim 1, wherein said catadioptric section has a magnification β_M greater than 0.95.

10. A projection lens according to claim 1, wherein said catadioptric section is corrected for spherical aberration such that the longitudinal spherical aberration, SAL, of said catadioptric section satisfies the following condition:

$0 < |SAL/L| < 0.025$, where L is the geometric distance between said object plane and said image plane.

11. A projection lens according to claim 1, wherein an intermediate-lens group with at least one lens is arranged in said catadioptric section between the beam-deflector and a mirror group, the mirror group including said concave mirror and at least one negative lens.

12. A projection lens according to claim 11, wherein said intermediate-lens group includes at least one positive lens.

13. A projection lens according to claim 1, wherein said beam-deflector has a first mirrored surface for deflecting radiation coming from said object plane to said concave mirror and a second mirrored surface, inclined at an angle with respect to said first mirrored surface, for deflecting radiation coming from said concave mirror to said dioptric section.

14. A projection lens according to claim 1, wherein said beam-deflector has only a single mirrored surface arranged such that it reflects radiation coming from the concave mirror to said dioptric section.

15. A projection lens according to claim 1, wherein a polarization-selective mirrored surface is arranged inside a beamsplitter cube.

16. A projection lens according to claim 1, wherein a lens with a positive refractive power is arranged between said object plane and said beam-deflector.

17. A projection lens according to claim 1, wherein a system stop is provided and wherein a curved, meniscus-shaped, air space is situated ahead of the system stop and close to the same.

18. A projection lens according to claim 1, wherein at least the image side is telecentrically designed.

19. A projection lens according claim 1, designed for use with ultraviolet light falling within the wavelength range extending from 120 nm to approximately 260 nm.

20. A projection illumination system for use in microlithography including an illumination system and a catadioptric projection lens for imaging a pattern situated in an object plane of the projection lens onto an image plane of the projection lens while creating a real intermediate image, the catadioptric projection lens comprising:

a catadioptric section with a concave mirror and a beam-deflector located between said object plane and said image plane; and

a dioptric section arranged following said beam-deflector;

wherein said dioptric section is located after a final reflective surface of said catadioptric section and comprises at least one lens arranged between said final reflective surface and said intermediate image; and

wherein said beam-deflector is a geometric beam splitter having at least one reflective surface.

21. A method for fabricating semiconductor devices, or other types of microdevices, comprising:

- providing a mask having a prescribed pattern,
 - illuminating said mask with ultraviolet light having a prescribed wavelength,
- and
- projecting an image of said pattern onto a photosensitive substrate situated in the vicinity of the image plane of a projection lens using a catadioptric projection lens having a catadioptric projection lens for imaging a pattern situated in an object plane of the projection lens onto an image plane of the projection lens while creating a real intermediate image, the projection lens including:

a catadioptric section with a concave mirror and a beam-deflector located between said object plane and said image plane; and

a dioptric section arranged following said beam-deflector;

said section starting after a final reflective surface of said catadioptric section and having at least one lens arranged between said final reflective surface and said intermediate image; and

said beam-deflector being a geometric beam splitter having at least one reflective surface.

22. A projection lens according to claim 1, wherein said catadioptric section has a magnification β_M greater than unity.

23. A catadioptric projection lens for imaging a pattern situated in an object plane of the projection lens onto an image plane of the projection lens while creating a real intermediate image, comprising:

a catadioptric section with a concave mirror and a beam-deflector located between said object plane and said image plane; and

a dioptric section arranged following said beam-deflector;

said dioptric section starting after a final reflective surface of said catadioptric section and comprising at least one lens arranged between said final reflective surface and said intermediate image; and

said beam-deflector having a first reflective surface for deflecting radiation coming from said object plane to said concave mirror and a second reflective surface, inclined at an angle with respect to said first reflective surface, for deflecting radiation coming from said concave mirror to said dioptric section.

24. A catadioptric projection lens for imaging a pattern situated in an object plane of the projection lens onto an image plane of the projection lens while creating a real intermediate image, comprising:

a catadioptric section with a concave mirror and a beam-deflector located between said object plane and said image plane; and

a dioptric section arranged following said beam-deflector;

said dioptric section starting after a final reflective surface of said catadioptric section and comprising at least one lens arranged between said final reflective surface and said intermediate image; and

said beam-deflector having only a single reflective surface arranged such that it reflects radiation coming from the concave mirror to said dioptric section.

25. A catadioptric projection lens for imaging a pattern situated in an object plane of the projection lens onto an image plane of the projection lens while creating at least one real intermediate image comprising:

a catadioptric imaging group with a concave mirror;

a geometric beam splitter having a reflective surface for reflecting radiation coming from the concave mirror towards the image plane; and

a dioptric imaging lens group arranged following said catadioptric imaging group;

wherein:

the catadioptric imaging group is arranged to create said intermediate image;

the dioptric imaging lens group is arranged to image said intermediate image onto the image plane; and

at least one lens is arranged between said reflective surface of the geometric beam splitter and said intermediate image.

26. A projection lens according to claim 25, wherein said intermediate image is situated freely accessible in an empty space at a distance from a nearest optical component.

27. A projection lens according to claim 25, wherein said intermediate image is situated at a distance from the reflective surface of the geometric beam splitter, where said distance is chosen such that the diameter of rays incident on a surface orthogonal to the

optical axis at an intersection of said reflective surface with said optical axis is at least 10 % of the diameter of said concave mirror.

28. A projection lens according to claim 25, wherein positive refractive power is arranged between said reflective surface of the geometric beam splitter and said intermediate image.

29. A projection lens according to claim 25, wherein a front lens is arranged on the object side ahead of said intermediate image and a rear lens is arranged on the image side following said intermediate image and wherein the front lens and the rear lens are roughly symmetrically arranged with respect to said intermediate image such that asymmetric contributions to imaging aberrations by the front lens and the rear lens due to heating of the front lens and the rear lens are at least partly compensated.

30. A projection lens according to claim 25, wherein a front lens is arranged on the object side ahead of said intermediate image and a rear lens is arranged on the image side following said intermediate image and wherein surfaces of the front lens and the rear lens facing said intermediate image are spherical.

31. A catadioptric projection lens for imaging a pattern situated in an object plane of the projection lens onto an image plane of the projection lens while creating at least one real intermediate image comprising:

a catadioptric section with a concave mirror and a geometric beam splitter having a reflective surface for reflecting radiation coming from the concave mirror towards the image plane; and

a dioptric section arranged following said catadioptric section; wherein:

the catadioptric section is arranged to create said intermediate image; and

at least one lens is arranged between said reflective surface and said intermediate image.

32. A projection lens according to claim 31, wherein said intermediate image is situated freely accessible in an empty space at a distance from a nearest optical component.

33. A projection lens according to claim 31, wherein said intermediate image is situated at a distance from the reflective surface of the geometric beam splitter, where said distance is chosen such that the diameter of rays incident on a surface orthogonal to the optical axis at an intersection of said reflective surface with said optical axis is at least 10 % of the diameter of said concave mirror.

34. A projection lens according to claim 31, wherein positive refractive power is arranged between said reflective surface of the geometric beam splitter and said intermediate image.

35. A projection lens according to claim 31, wherein a front lens is arranged on the object side ahead of said intermediate image and a rear lens is arranged on the image side following said intermediate image and wherein the front lens and the rear lens are roughly

symmetrically arranged with respect to said intermediate image such that asymmetric contributions to imaging aberrations by the front lens and the rear lens due to heating of the front lens and the rear lens are at least partly compensated.

36. A projection lens according to claim 31, wherein a front lens is arranged on the object side ahead of said intermediate image and a rear lens is arranged on the image side following said intermediate image and wherein surfaces of the front lens and the rear lens facing said intermediate image are spherical.

37. A catadioptric projection lens for imaging a pattern situated in an object plane of the projection lens onto an image plane of the projection lens while creating at least one real intermediate image comprising:

a catadioptric imaging group with a concave mirror and a geometric beam splitter having a first reflective surface; and

a dioptric imaging lens group arranged following said catadioptric imaging group; wherein:

the catadioptric imaging group is arranged to create said intermediate image;

the dioptric imaging lens group is arranged to image said intermediate image onto the image plane;

a second reflective surface is arranged within the dioptric imaging lens group between the intermediate image and the image plane; and

at least one lens is arranged between said intermediate image and said second reflective surface.

38. A projection lens according to claim 37, wherein said intermediate image is situated freely accessible in an empty space at a distance from a nearest optical component.

39. A projection lens according to claim 37, wherein said intermediate image is situated at a distance from the second reflective surface, where said distance is chosen such that the diameter of rays incident on a surface orthogonal to the optical axis at an intersection of said second reflective surface with said optical axis is at least 10 % of the diameter of said concave mirror.

40. A projection lens according to claim 37, wherein positive refractive power is arranged between said second reflective surface and said intermediate image.

41. A projection lens according to claim 37, wherein a front lens is arranged on the object side ahead of said intermediate image and a rear lens is arranged on the image side following said intermediate image and wherein the front lens and the rear lens are roughly symmetrically arranged with respect to said intermediate image such that asymmetric contributions to imaging aberrations by the front lens and the rear lens due to heating of the front lens and the rear lens are at least partly compensated.

42. A projection lens according to claim 37, wherein a front lens is arranged on the object side ahead of said intermediate image and a rear lens is arranged on the image side following said intermediate image and wherein the front lens and the rear lens have positive refractive power.